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(54) **HYBRID COMPOSITE UTILIZING GAS-ASSISTED MOLDING GEOMETRIES**

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B62D 29/04	(2006.01)
B62D 25/14	(2006.01)
B62D 27/02	(2006.01)

(Continued)

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(58) **Field of Classification Search**

CPC B60K 37/00; B62D 25/14; B62D 43/003; B62D 47/0004

USPC 296/70; 180/90

See application file for complete search history.

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Primary Examiner — James English

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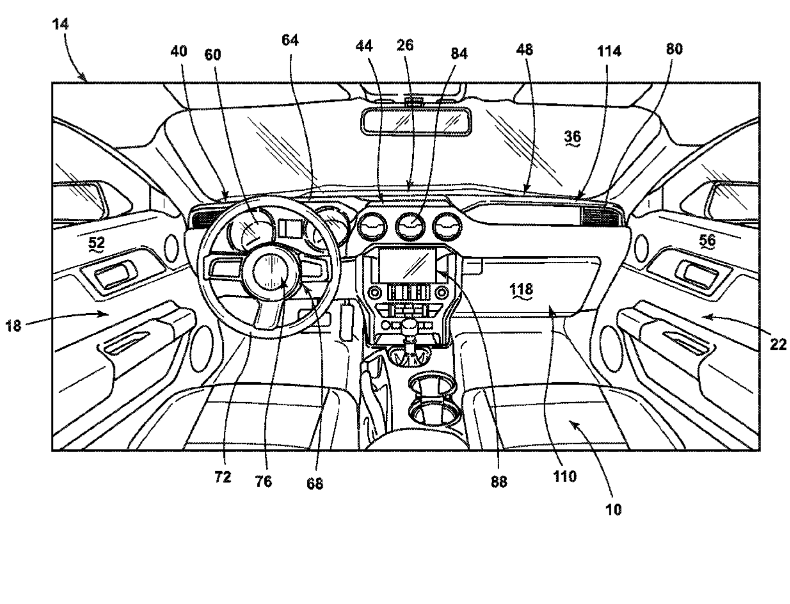
(57) **ABSTRACT**

A vehicular instrument panel includes a substrate having a first plurality of chopped carbon fibers and a first plurality of chopped glass fibers within a first nylon resin. The first plurality of chopped carbon fibers and the first plurality of glass fibers in the substrate are segregated such that the carbon fibers and the glass fibers are each substantially concentrated within respective driver-side and passenger-side portions of the substrate. A reinforcement includes a second plurality of chopped carbon fibers within a second nylon resin. A reinforcement rib is integrally defined by the reinforcement. The reinforcement rib is substantially hollow and positioned on a driver-side portion of the reinforcement. A substrate rib is integrally defined by the substrate. The substrate rib is substantially hollow and positioned on the driver-side portion of the substrate. The substrate rib and the reinforcement rib are bonded to one another.

20 Claims, 8 Drawing Sheets



(51) **Int. Cl.**

B29C 45/16	(2006.01)
B29C 45/17	(2006.01)
B29L 31/30	(2006.01)
B29K 105/12	(2006.01)

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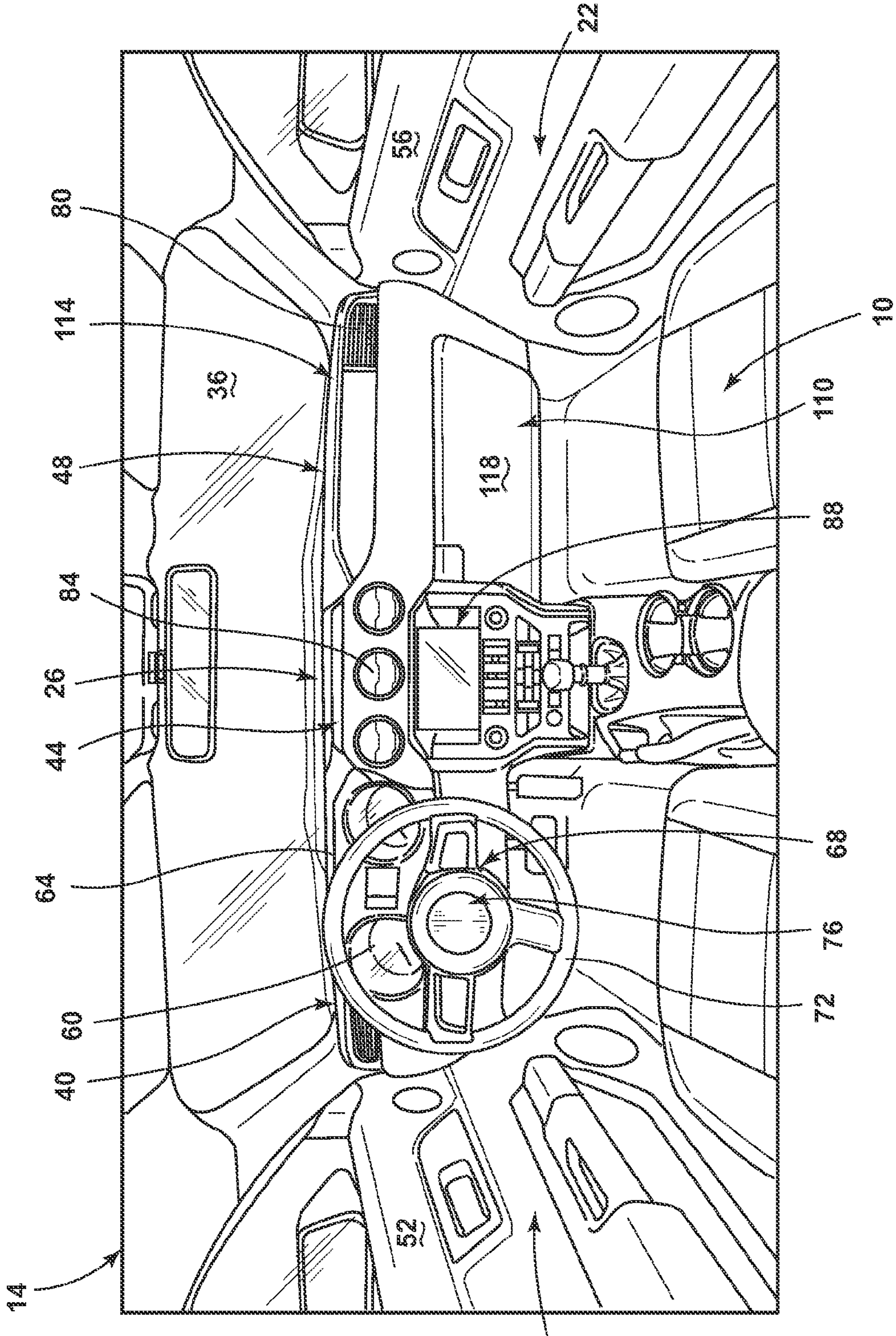

FIG. 1

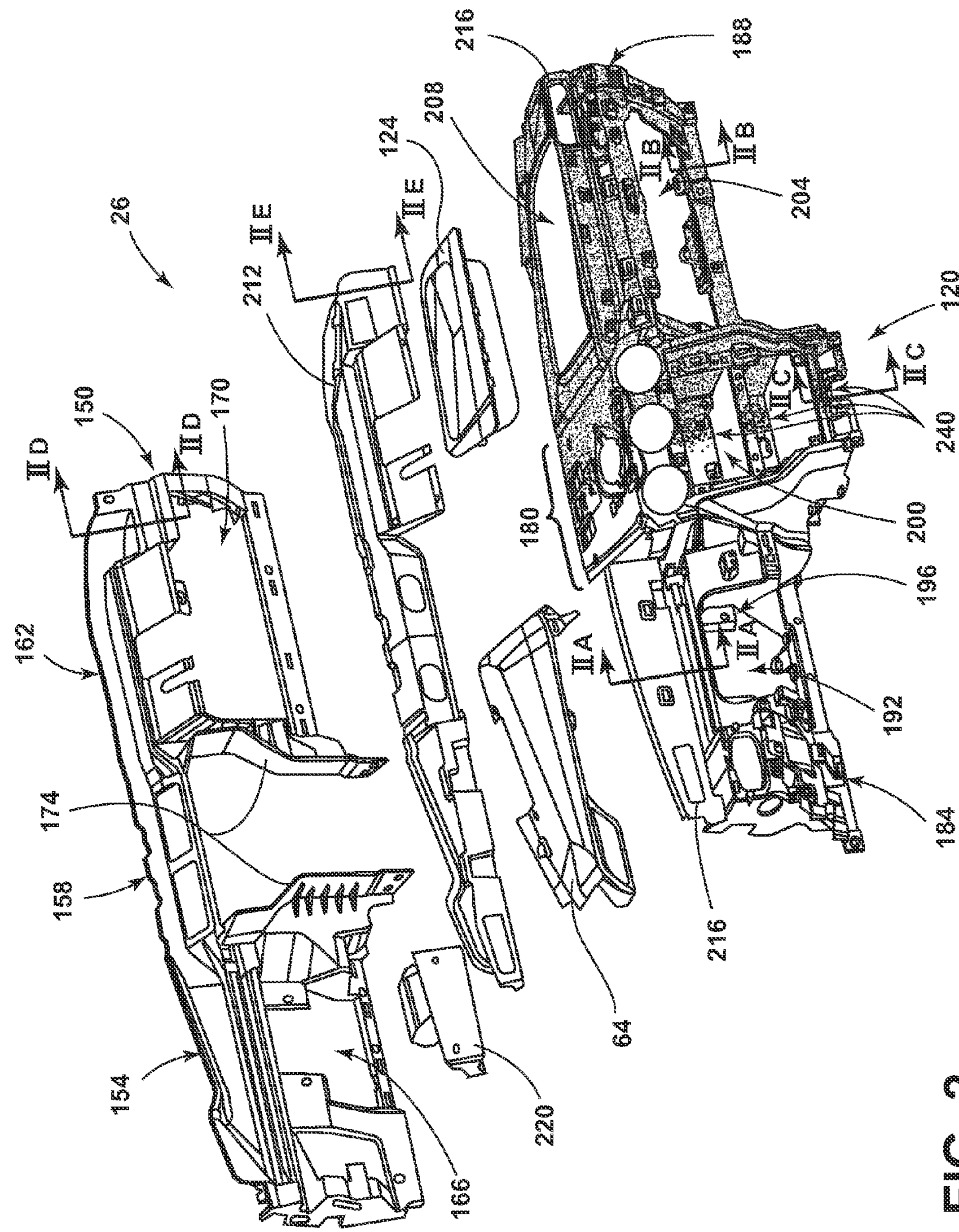
26
150
170
162
174
158
154
166
220
212
124
208
216
188
204
120
240
200
180
196
192
184
64
II A
II B
II C
II D
II E

FIG. 2

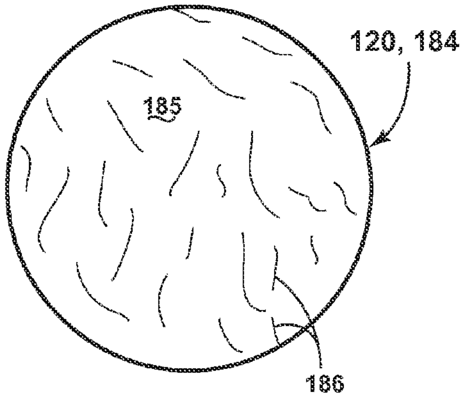

FIG. 2A

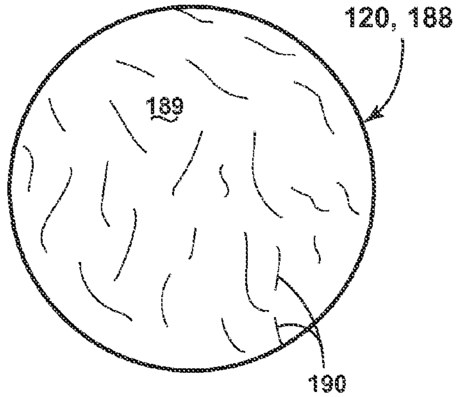

FIG. 2B

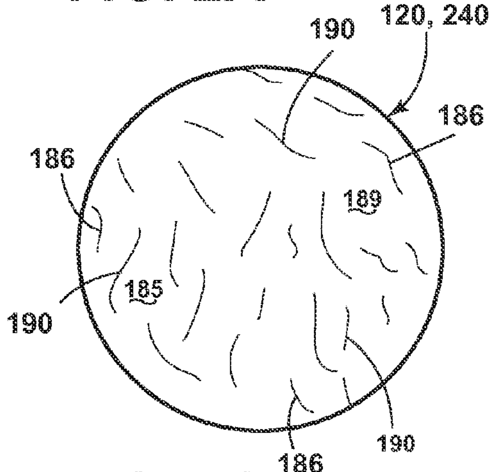

FIG. 2C

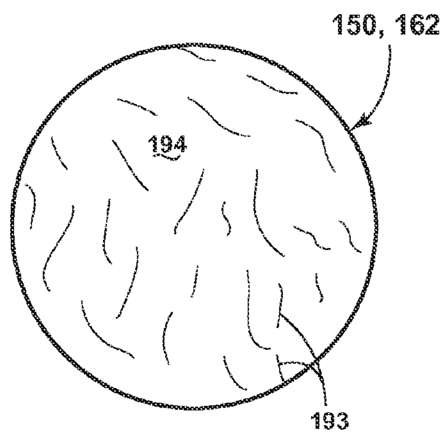

FIG. 2D

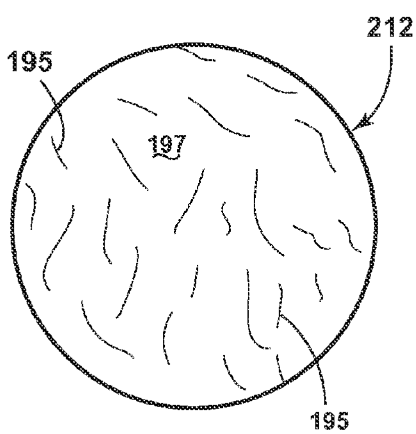

FIG. 2E

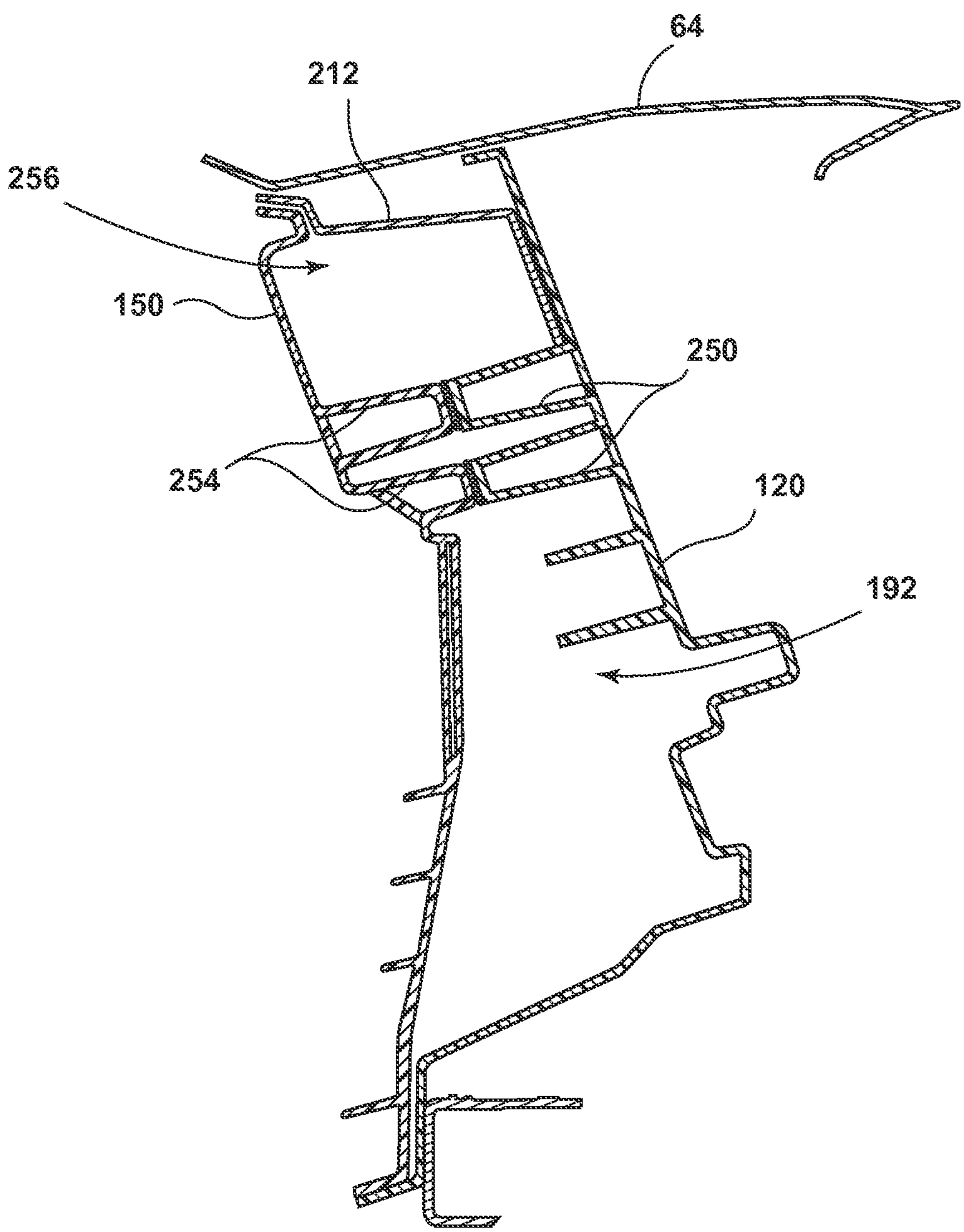

FIG. 3

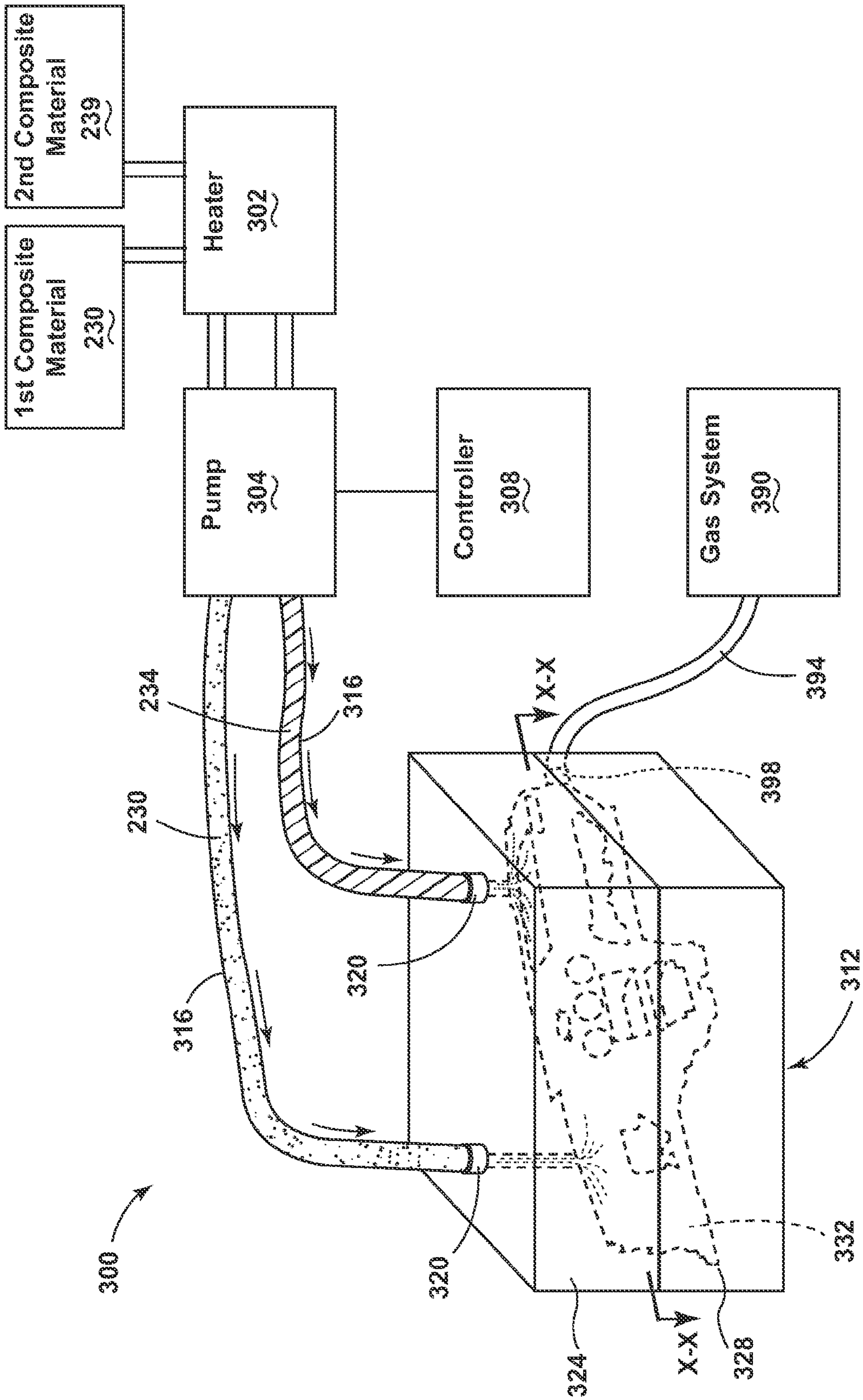
1st Composite Material 230
2nd Composite Material 239
Heater 302
Pump 304
Controller 308
Gas System 390
234
316
230
316
320
320
398
394
X-X
X-X
300
312
324
328
332

FIG. 4

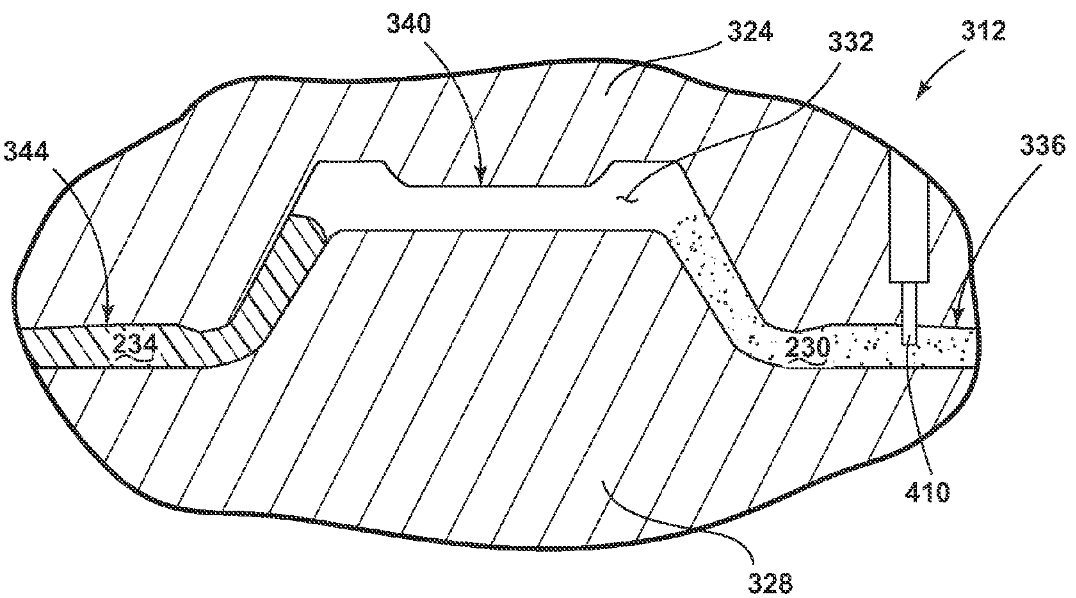

FIG. 5A

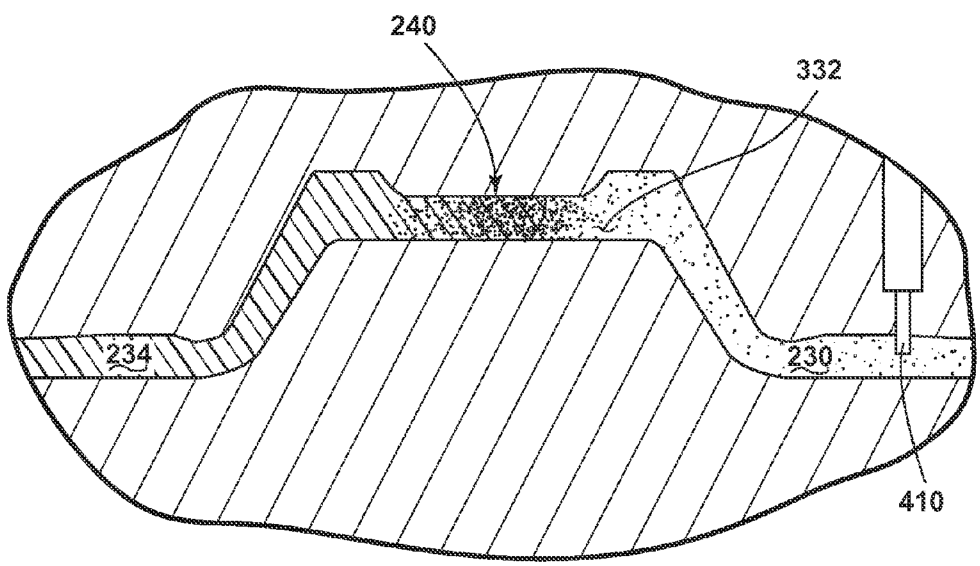

FIG. 5B

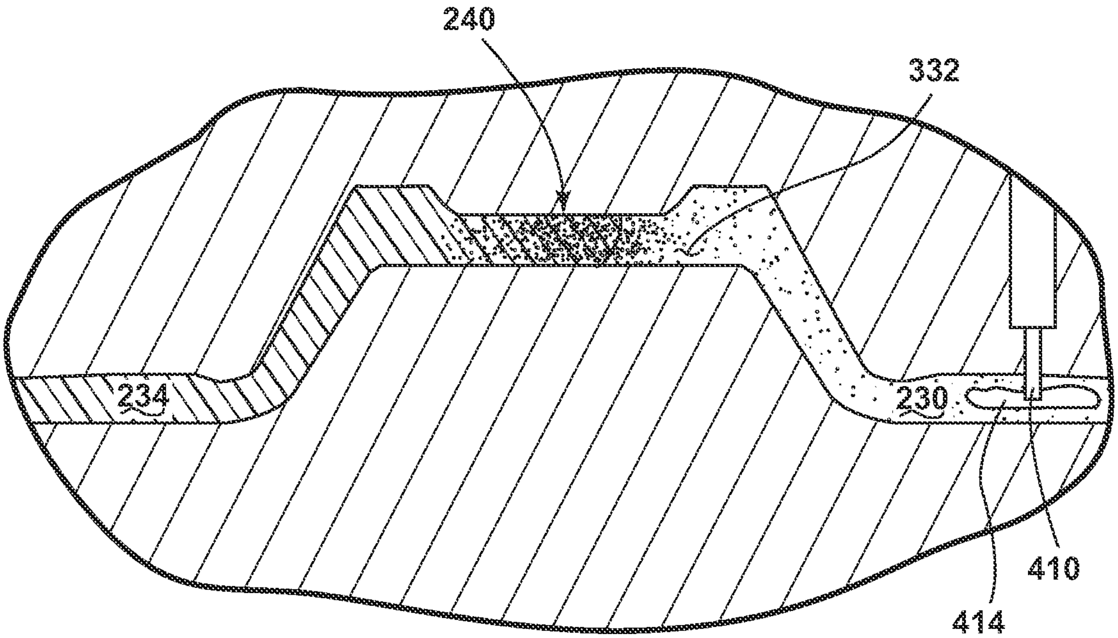

FIG. 5C

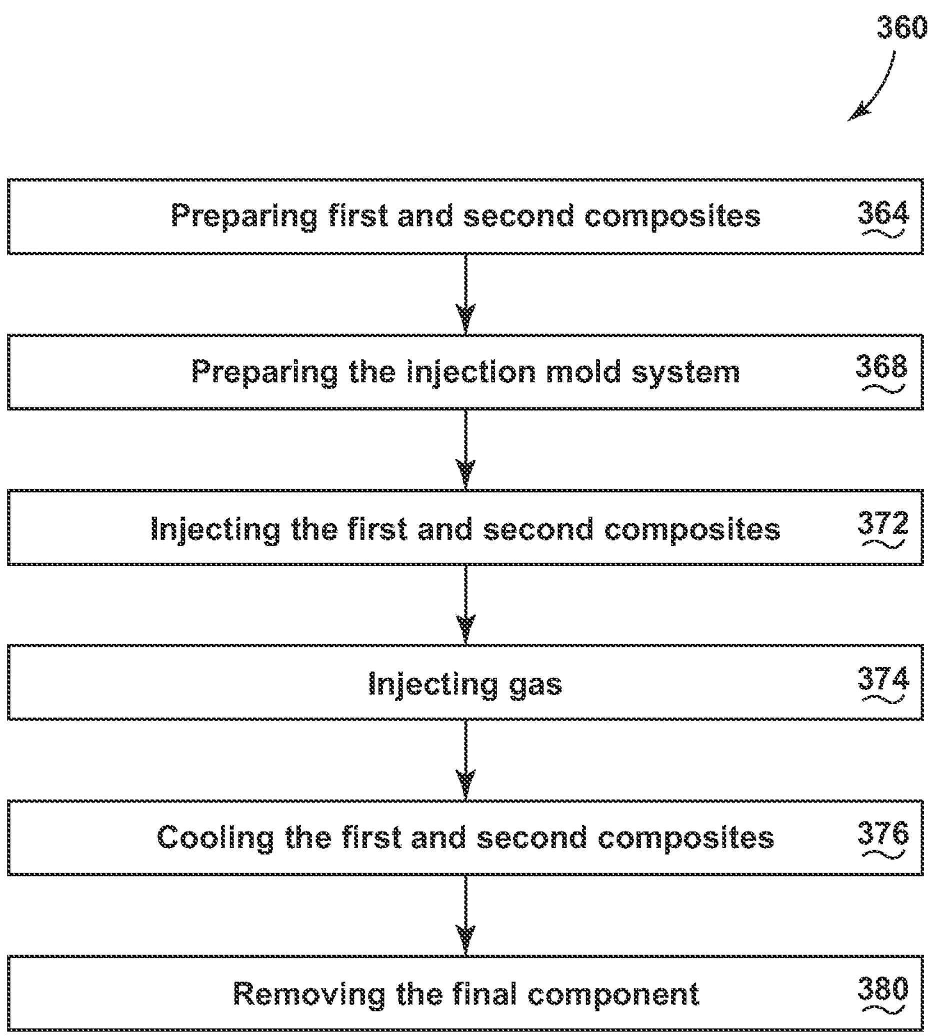
360
Preparing first and second composites 364
Preparing the injection mold system 368
Injecting the first and second composites 372
Injecting gas 374
Cooling the first and second composites 376
Removing the final component 380

FIG. 6

HYBRID COMPOSITE UTILIZING GAS-ASSISTED MOLDING GEOMETRIES

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation-in-part application that claims priority to and the benefit under 35 U.S.C. §120 of U.S. patent application Ser. No. 14/270,951 filed on May 6, 2014, now issued as U.S. Pat. No. 9,186,993, entitled "HYBRID COMPOSITE INSTRUMENT PANEL," the entire disclosure of which is hereby incorporated herein by reference.

FIELD OF THE INVENTION

The present disclosure generally relates to composite component designs, and more particularly relates to composite vehicular instrument panel designs and methods for making the same.

BACKGROUND OF THE INVENTION

It is becoming more common for vehicles to utilize lightweight components and designs in order to decrease vehicle weight, particularly in large, interior vehicle components such as instrument panels. Weight reductions can increase vehicle performance and fuel economy. Weight savings may be realized by substituting current materials of vehicle components with lighter weight materials. However, in some cases, lighter weight materials employed in vehicles can have less mechanical integrity than their heavier weight counterparts.

In other cases, certain lighter weight materials, such as carbon fiber composites, can actually have improved mechanical performance over conventional materials. Unfortunately, the manufacturing costs of making vehicular components with these materials can be prohibitive or at least not low enough to offset the potential improvements in vehicle performance and fuel economy. Further, these stronger composite materials are often employed in large vehicular components that have only one, or a handful, of regions that actually require elevated mechanical performance.

Accordingly, there is a need for lighter-weight vehicular components having better or comparable mechanical performance when compared to conventional vehicular components. There is also a need to tailor the mechanical properties in particular regions within these components for the particular application, thus minimizing the use of expensive reinforcing materials and maximizing mechanical property enhancements where it is required in the component.

SUMMARY OF THE INVENTION

According to one aspect of this invention, a vehicular instrument panel includes a substrate having a first plurality of chopped carbon fibers and a first plurality of chopped glass fibers within a first nylon resin. The first plurality of chopped carbon fibers and the first plurality of glass fibers in the substrate are segregated such that the carbon fibers and the glass fibers are each substantially concentrated within respective driver-side and passenger-side portions of the substrate. A reinforcement is coupled to the substrate and includes a second plurality of chopped carbon fibers within a second nylon resin. A reinforcement rib is integrally defined by the reinforcement. The reinforcement rib is substantially hollow and positioned on a driver-side portion of the reinforcement. A substrate rib is integrally defined by the substrate. The substrate rib is substantially hollow and positioned on the driver-side portion of the substrate. The substrate rib and the reinforcement rib are bonded to one another.

According to another aspect of this invention, a vehicular instrument panel includes a first member having a fiber material within a first resin. The first member defines a first hollow rib. A second member is coupled to the first member and has driver-side, passenger-side, and center-stack portions. The second member defines a second hollow rib in the driver-side portion which is bonded to the first hollow rib. The driver-side portion includes a first fiber material within a second resin, the passenger-side portion comprises a second fiber material within the second resin, and the center-stack portion comprises a mixture of the first and second fiber materials within the second resin.

According to yet another aspect of this invention, a vehicular instrument panel includes a reinforcement having a plurality of chopped carbon fibers within a nylon resin. The reinforcement has a hollow reinforcement rib. A substrate is coupled to the reinforcement and includes a plurality of chopped carbon and chopped glass fibers segregated into respective driver-side and passenger-side portions. The substrate has a hollow substrate rib. The reinforcement rib and the substrate rib are bonded to one another.

These and other features, advantages, and objects of the present invention will be further understood and appreciated by those skilled in the art by reference to the following specification, claims, and appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a front perspective view of a vehicular instrument panel within a vehicle according to one embodiment;

FIG. **2** is an exploded top perspective view of the instrument panel depicted in FIG. **1**;

FIG. **2**A is an enhanced cross sectional view of the instrument panel of FIG. **2**, taken at IIA-IIA;

FIG. **2**B is an enhanced cross sectional view of the instrument panel of FIG. **2**, taken at IIB-IIB;

FIG. **2**C is an enhanced cross sectional view of the instrument panel of FIG. **2**, taken at IIC-IIC;

FIG. **2**D is an enhanced cross sectional view of the instrument panel of FIG. **2**, taken at IID-IID;

FIG. **2**E is an enhanced cross sectional view of the instrument panel of FIG. **2**, taken at IIE-IIE;

FIG. **3** a cross-sectional view of the instrument panel of FIG. **2** in assembly, taken at line III-III;

FIG. **4** is a top perspective view of an injection molding system according to an additional embodiment;

FIG. **5**A is a cross-sectional view of the injection molding system of FIG. **4** during a step of injecting molten composites into a mold, taken at line X-X;

FIG. **5**B is a cross-sectional view of the injection molding system of FIG. **4** during a step of mixing the melted composites, taken at line X-X;

FIG. **5**C is a cross-sectional view of the injection molding system of FIG. **4** during a step of injecting gas into the melted composites, taken at line X-X; and

FIG. **6** is a schematic of a method for forming a vehicular component using the injection molding system of FIG. **4** according to another embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

For purposes of description herein, the terms "upper," "lower," "right," "left," "rear," "front," "vertical," "horizontal," and derivatives thereof shall relate to the disclosure as oriented in FIG. **1**. However, it is to be understood that the disclosure may assume various alternative orientations, except where expressly specified to the contrary. It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described in the following specification are simply exemplary embodiments of the inventive concepts defined in the appended claims. Hence, specific dimensions and other physical characteristics relating to the embodiments disclosed herein are not to be considered as limiting, unless the claims expressly state otherwise.

Referring to FIG. **1**, a cabin **10** of a vehicle **14** is depicted. The vehicle **14** includes a driver-side region **18** and a passenger-side region **22**. Inside the cabin **10** is an instrument panel **26**, among other vehicle components, such as a windshield **36**. The instrument panel **26** is located vehicle forward of the passenger seating in the cabin **10** and generally beneath the windshield **36**. The instrument panel **26** has a driver-side portion **40**, a center-stack portion **44**, and a passenger-side portion **48**. These portions of the instrument panel **26**, and particular regions or locations within them, often have differing mechanical property requirements.

As used in this disclosure, "outboard" refers to the lateral sides or regions most proximate to a driver-side door **52** and a passenger-side door **56** in the vehicle **14**. The term "inboard" as used in this disclosure refers to a central area in the vehicle **14** inboard from the laterally opposing outboard sides or regions.

The driver-side and passenger-side portions **40**, **48** of the instrument panel **26** are in substantial proximity to respective driver-side and passenger-side regions **18**, **22** of the vehicle **14**. The driver-side portion **40** of the instrument panel **26** includes an instrument cluster **60** covered by an instrument cluster hood **64**. Located below the instrument cluster **60** is a steering column **68**. The steering column **68** is supported by the instrument panel **26** and engages a steering system (not shown) vehicle forward of the instrument panel **26**. The steering column **68** extends from the steering system into the cabin **10** through the instrument panel **26**. The steering column **68** has a steering wheel **72** disposed in the cabin **10** in the driver-side region **18** of the vehicle **14**. The steering wheel **72** includes a driver airbag **76** which is deployable upon experiencing a sufficient vehicle collision event. As such, the driver-side portion **40** of the instrument panel **26** can have demanding mechanical requirements, particularly at locations where it must support other vehicular components subject to variable loads and motion, e.g., steering column **68**.

Disposed on each outboard side of the instrument panel **26** is a side air vent **80**. The instrument panel **26** also incorporates a set of central air vents **84** located in the center-stack portion **44** of the instrument panel **26**. The center-stack portion **44** of the instrument panel **26** is located between the driver-side portion **40** and the passenger-side portion **48**. The center-stack portion **44** includes an interface **88** that is operable by occupants of both the driver-side and the passenger-side regions **18**, **22** of the vehicle **14**. The center-stack portion **44** is connected to both the driver-side portion **40** and the passenger-side portion **48** of the instrument panel **26**.

As also depicted in FIG. **1**, the passenger-side portion **48** of the instrument panel **26** includes a glove box assembly **110**, and a passenger airbag assembly **114** that is located above the assembly **110**. The glove box assembly **110** includes a glove box door **118** permitting access to a glove box bin (not shown). In some embodiments, the glove box assembly **110** is a separate component from the instrument panel **26** and is inserted and attached during vehicle manufacturing. In other embodiments, the glove box bin of the assembly **110** is integrally formed from an instrument panel substrate **120** (FIG. **2**) of the instrument panel **26** and the glove box door **118** is a separate component that is attached during manufacturing. Depending on the configuration of passenger-side portion **48**, it may have central regions or locations that require additional mechanical reinforcement, such as where it contains or attaches to glove box assembly **110**.

The passenger airbag assembly **114** includes a passenger airbag chute **124** (FIG. **2**), and other components such as a passenger airbag, an airbag canister, and an inflator. During a vehicle collision event, the passenger airbag is inflated by the inflator (not shown), thereby causing the passenger airbag to expand from the canister through the passenger airbag chute **124** (FIG. **2**) and out of the instrument panel **26**. The inflation and expansion of the airbag generates high stresses in surrounding components which can lead to structural failure of the instrument panel **26** if not properly reinforced. In some embodiments, the instrument panel substrate **120** (FIG. **2**) of the instrument panel **26** may also include knee airbag canisters for the occupants of both the driver-side and passenger-side regions **18**, **22**, potentially necessitating additional reinforcement.

Referring now to FIG. **2**, the instrument panel **26** includes the instrument panel substrate **120** and a reinforcement **150**. The reinforcement **150** is located vehicle forward of the substrate **120** and is coupled to the substrate **120** at multiple points. The substrate **120** and the reinforcement **150** may be coupled via adhesive bonding, vibration welding, hot plate welding, or other forms of joining. The reinforcement **150** includes a driver-side portion **154**, a center-stack portion **158**, and a passenger-side portion **162**. The reinforcement **150** defines a steering column aperture **166** and a glove box aperture **170** on the respective driver-side and passenger-side portions **154**, **162**. Flanges **174** are located within the center-stack portion **158** of the reinforcement **150** and extend vehicle rearward to engage and couple with a center-stack portion **180** of the substrate **120**.

As also depicted in FIG. **2**, the instrument panel substrate **120** includes a driver-side portion **184**, the center-stack portion **180**, and a passenger-side portion **188**. The driver-side portion **184** of the substrate **120** defines a steering column opening **192** which aligns with the steering column aperture **166** of the reinforcement **150** when the substrate **120** and the reinforcement **150** are coupled. The steering column **68** (FIG. **1**) passes through both the steering column aperture **166** and the steering column opening **192**, and is attached to the substrate **120** via a steering column mounting area **196**, as shown in FIG. **2**. The steering column mounting area **196** is located on the substrate **120** proximate to the steering column opening **192**. In some embodiments, a jacket for the steering column **68** may be integrally formed in the substrate **120** proximate to the mounting area **196**. In other embodiments, a mounting bracket or a support bracket may be integrally formed in the substrate **120** proximate to the steering column opening **192** for supporting the steering column **68**. The coupling of the reinforcement **150** to the substrate **120** provides sufficient strength for the mounting area **196**, and ultimately the instrument panel **26**, to support the weight of the steering column **68** without the use of a cross car beam. As such, certain regions or locations in the driver-side portion **184** of the substrate **120** may require and/or benefit from additional reinforcement.

The center-stack portion **180** of the instrument panel substrate **120** includes an electronics bay **200** for housing and mounting the interface **88** (FIG. **1**) as well as other electronic components. The center-stack portion **180** is located between and is integrally connected to both the driver-side and passenger-side portions **184**, **188** of the substrate **120**. Depending on the electronic components and other components deployed in the center-stack portion **180**, additional localized reinforcement in the substrate **120** with hybrid composites in these regions could provide mechanical performance and/or weight savings benefits.

The passenger-side portion **188** of the instrument panel substrate **120** defines a glove box opening **204** and a passenger airbag assembly opening **208** for housing the respective glove box assembly **110** (FIG. **1**) and passenger airbag assembly **114** (FIG. **1**). In some embodiments, the substrate **120** may be configured to further define a glove box bin and/or an airbag canister as integral bodies that extend from the respective glove box and passenger airbag assembly openings **204**, **208**. In other embodiments, the reinforcement **150** could be configured to define a glove box bin and/or an airbag canister. The substrate **120** and the reinforcement **150** can also be configured to define knee airbag canisters.

A duct **212** is located between the instrument panel substrate **120** and the reinforcement **150**. The duct **212** conveys air when bonded to the reinforcement **150**. The air travels though the duct **212** to a set of substrate vent openings **216** which direct the air to the side and central air vents **80**, **84** of the instrument panel **26** (FIG. **1**). Attached to the reinforcement **150** is a plenum bracket **220** which connects with a firewall (not shown) of the vehicle **14**. The plenum bracket **220** prevents bending of the instrument panel **26** in a vehicle forward and rearward direction. The plenum bracket **220** can also provide additional support for the steering column **68** (FIG. **1**), coupled to the substrate **120**.

Referring again to FIG. **2**, the instrument panel substrate **120** is formed from a hybrid composite material according to an embodiment of this disclosure. In one exemplary embodiment, the driver-side portion **184** can be formed from a nylon resin having chopped carbon fibers disposed in the resin. The passenger-side portion **188** can be formed from a nylon resin having chopped glass fibers disposed in the resin. In general, regions in the substrate **120** with higher percentages of chopped carbon fibers can have enhanced mechanical properties (e.g., toughness, tensile strength, fatigue resistance). The carbon fiber volume fraction and the glass fiber volume fraction in the passenger-side and driver-side portions **184**, **188** may be between about 1% and about 60%, preferably between about 15% and about 40%, and more preferably between about 30% to about 40%. In some embodiments, the fiber volume fraction in the driver-side portion **184** may be different from the fiber volume fraction in the passenger-side portion **188** of the substrate **120**. In additional embodiments, areas of the substrate **120** that are anticipated to encounter high stresses are configured to incorporate higher fiber volume fractions of chopped carbon fibers than areas not expected to experience high stresses. For example, the mounting area **196** may incorporate a higher fiber volume fraction, particularly of chopped carbon fibers, than the rest of the driver-side portion **184** of the substrate **120** to aid in supporting the steering column **68**. In another example, the surfaces of the instrument panel substrate **120** and reinforcement **150** subject to high stress during airbag deployment may incorporate higher fiber volume fractions. In further embodiments, the driver-side and passenger-side portions **184**, **188** of the substrate **120** may incorporate more than two composite materials.

In some embodiments, the fibers employed in the driver-side and passenger-side portions **184**, **188** of the instrument panel substrate **120** can be composed of materials including carbons, aramids, aluminum metals, aluminum oxides, steels, borons, silicas, silicon carbides, silicon nitrides, ultra-high-molecular-weight polyethylenes, A-glasses, E-glasses, E-CR-glasses, C glasses, D-glasses, R-glasses, and S-glasses. Driver-side and passenger-side portions **184**, **188** may also incorporate more than one type of fiber. In some embodiments, the length of the chopped fibers can be between about 3 mm and about 11 mm, and more preferably between about 5 mm and about 7 mm. Typically, the fibers are randomly oriented in the resins within the driver-side and passenger-side portions **184**, **188**. However, they may also be substantially aligned directionally in areas of the substrate **120** subject to high directional stresses. Further, the resins employed in the driver-side and passenger-side portions **184**, **188** can comprise a nylon, a polypropylene, an epoxy, a polyester, a vinyl ester, a polyetheretherketone, a poly(phenylene sulfide), a polyetherimide, a polycarbonate, a silicone, a polyimide, a poly(ether sulfone), a melamine-formaldehyde, a phenol-formaldehyde, and a polybenzimidazole, or combinations thereof. In some embodiments, the resin of the driver-side portion **184** may be different from the resin employed in the passenger-side portion **188** of the substrate **120**. It should also be understood that the reinforcement **150** and its driver-side, center-stack and passenger-side portions **154**, **158**, **162** can be fabricated with hybrid composite materials comparable to those described above in connection with substrate **120**. For example, the driver-side portion **154** of the reinforcement **150** can be formed from a nylon resin having chopped carbon fibers disposed in the resin. The passenger-side portion **162** can be formed from a nylon resin having chopped glass fibers disposed in the resin. Further, the volume fraction of the fibers in the resins, preferably the chopped carbon fibers, may be greater in areas subject to higher stress levels than in other areas or the rest of the reinforcement **150**.

Still referring to FIG. **2**, the chopped carbon and glass fibers are segregated in the substrate **120** of the instrument panel **26** such that the carbon fibers are substantially concentrated in the driver-side portion **184** of the substrate **120** and the glass fibers are substantially concentrated in the passenger-side portion **188** of the substrate **120**. In general, the center-stack portion **180** of the substrate **120** is composed of both chopped carbon and glass fibers. In some embodiments, the center-stack portion **180** may primarily include carbon fibers, or primarily glass fibers. In other embodiments, the carbon fibers primarily contained in the driver-side portion **184** may also partially occupy the passenger-side portion **188** of the substrate **120**. In further embodiments, the carbon fibers primarily in the driver-side portion **184** may also occupy portions of the substrate **120** which are subject to high stress, regardless of passenger-side or driver-side orientation. For example, airbag deployment surfaces located in or on the substrate **120** or reinforcement **150** can include higher percentages of carbon fibers for additional mechanical reinforcement. The segregation of the fibers, e.g., chopped carbon and glass fibers, in the substrate **120** allows the higher strength fiber, e.g., carbon fiber, to be selectively used where there are particular high strength needs for the substrate **120**, such as to support the steering column **68**. The selective use of high percentages of carbon fibers based on driver/passenger orientation relative to the vehicle **14** allows a cost savings by efficiently using the more expensive carbon fibers only where needed.

A boundary region **240** can exist in some embodiments at the interface between the driver-side and passenger-side portions **184**, **188** of the instrument panel substrate **120**. The boundary region **240** includes a mixture of both types of fibers and resin(s) employed in the driver-side and passenger-side portions **184**, **188** of the substrate **120**. The mixing of fibers within the boundary region **240** ensures that an integral connection exists between portions of the substrate **120** composed of different composite materials. In one embodiment, the boundary region **240** may span or otherwise encompass the entire center-stack portion **180** of the substrate **120**. In another embodiment, the boundary region **240** may be present only between the center-stack and passenger-side portions **180**, **188**, or between the driver-side and center-stack portions **184**, **180** of the substrate **120**. The boundary region **240** can also be located anywhere in the substrate **120** where there is an interface between portions of the substrate **120** containing differing fiber fractions, fiber types and/or resins. In one exemplary embodiment, driver-side portion **184** may have an approximate 30% to 40% volume fraction of chopped carbon fibers in a resin, the passenger-side portion **188** may have an approximate 30% to 40% volume fraction of chopped glass fibers in the resin, and the center-stack portion **180** or the boundary region **240** may have an approximate 15% to 20% volume fraction of chopped carbon fibers and an approximate 15% to 20% volume fraction of chopped glass fibers in the resin. In this configuration, the driver-side portion **184** is particularly reinforced with higher percentages of chopped carbon fibers relative to other portions of the substrate **120**.

Referring now to the depicted embodiments of FIGS. **2**A-E, the driver-side portion of the substrate **120** is depicted as having a first plurality of chopped carbon fibers **186** disposed in a first nylon resin **185**. The passenger-side portion **188** of the substrate **120** is depicted as having a first plurality of glass fibers **190** disposed in a second nylon resin **189**. As explained above, the boundary region **240** within the substrate **120** includes a mixture of the first plurality of chopped carbon fibers **186**, the first plurality of chopped glass fibers **190**, the first nylon resin **185**, and the second nylon resin **189**. The reinforcement **150** includes a second plurality of chopped carbon fibers **193** disposed in a third nylon resin **194**. The duct **212** includes a second plurality of chopped glass fibers **195** disposed in a fourth nylon resin **197**.

According to some embodiments, the instrument panel substrate **120** and/or the reinforcement **150** of the instrument panel **26** may incorporate one or more preformed fiber mats in addition to the portions containing chopped fibers in a resin or resins. The preformed fiber mats may include woven or non-woven fibers that are held together using the same or different resins as employed in the driver-side and passenger-side portions **184**, **188** of the substrate **120**. The mats may also incorporate fibers having different dimensions from the fibers employed in the driver-side and passenger-side portions **184**, **188** of the substrate **120**. Similarly, the fibers of the mats may be in either a continuous or chopped configuration. The fibers of the mats may also be composed of a material having the same or a different composition from that of the fibers employed in the driver-side and passenger-side portions **184**, **188** of the substrate **120**. The mats may be incorporated in areas of the substrate **120** and/or the reinforcement **150** having high or low fiber volume fractions. Multiple mats may be used and layered in varying orientations in order to further enhance the mechanical properties of the substrate **120** and/or reinforcement **150** at particular locations. Exemplary locations in the substrate **120** for placement of the mat include, but are not limited to: the steering column mounting area **196**, airbag assembly opening **208**, glove box opening **204**, coupling locations between the reinforcement **150** and the substrate **120**, and other locations anticipated to experience higher stress levels compared to stresses in other areas of the substrate **120**.

The utilization of a hybrid composite containing carbon fibers in the substrate **120** and the reinforcement **150** permits the vehicle **14** to be designed and manufactured without a cross car beam. Conventional cross car beams are thick metal components traditionally used to support the instrument panel **26** and the steering column **68** of the vehicle **14**. In addition to adding significant weight to the vehicle **14**, the cross car beam occupies a potential storage space behind the instrument panel **26** and obstructs placement of the passenger airbag assembly **114** and the glove box assembly **110**. Without the cross car beam, the vehicle **14** can achieve greater fuel efficiency as well as enhanced design freedom for the instrument panel **26** and its subassemblies.

Referring now to the embodiment depicted in FIGS. **2** and **3**, the substrate **120** integrally defines substrate ribs **250** and the reinforcement **150** integrally defines reinforcement ribs **254**. The substrate ribs **250** and the reinforcement ribs **254** may be defined by any part of the substrate **120** or the reinforcement **150** prone to high stresses (e.g., proximate the steering column mount **196**, glove box opening **204**, passenger airbag opening **208**, connection points between components, and/or boundary region **240**). Although the substrate **120** and the reinforcement **150** are each depicted as defining two ribs **250**, **254**, it should be understood that one or more ribs **250**, **254** are contemplated. The substrate ribs **250** are positioned above the steering column opening **192** of the substrate **120** and adjacent the mounting area **196**. The reinforcement ribs **254** are positioned above the steering column aperture **166** of the reinforcement **150**. Additionally or alternatively, substrate ribs **250** and reinforcement ribs **254** may be located throughout the respective substrate **120** and reinforcement **150**. The substrate and reinforcement ribs **250**, **254** are continuous structures extending along the driver-side portions **184**, **154** of the substrate and reinforcement **120**, **150**, but may also be discontinuous or intermittent structures. The substrate ribs **250** extend only over the steering column opening **192**, but may also extend the entire length of the driver-side portion **184** or any length there between. Similarly to the substrate ribs **250**, the reinforcement ribs **254** may also extend over any length of the driver-side portion **154** of the reinforcement **150**. In embodiments where the substrate **120** and/or the reinforcement **150** define more than one rib **250**, **254**, the ribs may be discrete structures or connected in a branched structure and spaced apart. In the depicted embodiment, the substrate ribs **250** run parallel to one another, but are also contemplated to range in orientation between parallel and perpendicular. Similarly to that described in connection with the substrate ribs **250**, the reinforcement ribs **254** may also take a variety of orientations to one another.

Referring now to FIG. **3**, the substrate ribs **250** and the reinforcement ribs **254** are substantially hollow along the length of the ribs **250**, **254**. For the purposes of this disclosure, "substantially hollow" refers to the ribs **250**, **254** being largely free of blockages, however, it is contemplated that flashing, as well as reinforcing geometries, may be employed within the ribs **250**, **254** that may partially obstruct the ribs **250**, **254** without departing from the spirit of this disclosure. The substrate ribs **250** and the reinforcement ribs **254** are formed during the formation of the substrate **120** and the reinforcement **150**, respectively. Although depicted as substantially trapezoidal in shape, the substrate and reinforcement ribs **250**, **254** may be squared, rounded, or domed. In some embodiments, the ribs **250**, **254** may be formed through the joining of sub-assemblies of the substrate **120** and reinforcement **150**.

In assembly, the substrate ribs **250** and the reinforcement ribs **254** are configured to be bonded to one another in order to secure the substrate **120** and the reinforcement **150** together. In the depicted trapezoidal configuration, a surface of the substrate ribs **250** is bonded to a surface of the reinforcement ribs **254**. In some embodiments, the substrate ribs **250** and the reinforcement ribs **254** may be configured to have more than one surface to be bonded together on. Additionally or alternatively, the substrate ribs **250** and the reinforcement ribs **254** may be configured to interlock or mate. For example, the substrate ribs **250** and the reinforcement ribs **254** may jointly define a snap fastener, click fastener, or other mechanical fastening protrusions and apertures. In non-mechanical bonding techniques, the ribs **250**, **254** are bonded via adhesive bonding, vibration welding, hot plate welding, or other chemical and thermal forms of joining. In a particular embodiment, the ribs **250**, **254** are bonded using a urethane based adhesive. Although only depicted as bonded proximate the steering column opening **192**, it should be understood that substrate ribs **250** and reinforcement ribs **254** may be bonded at any point along the substrate **120** and reinforcement **150** where both are present. The substrate and reinforcement ribs **250**, **254**, when bonded together, cooperate with the duct **212** and the reinforcement **150** to define a hollow tube **256** which may function as a pseudo cross car beam while also functioning to transport air through the instrument panel **26**.

Integrally defining ribs **250**, **254** into the substrate **120** and the reinforcement **150** allows for an increase in the stiffness of the substrate **120** and the reinforcement **150** without a proportional increase in the amount of material used. The decreased usage of material directly leads to weight and cost savings, particularly in embodiments utilizing carbon fiber. The three dimensional structure of the ribs **250**, **254** resists bending by the substrate **120** and the reinforcement **150**, thereby increasing the strength of the instrument panel **26**. Additionally, by positioning the ribs **250**, **254** in areas prone to high stresses (e.g., proximate the steering column mount **196**, the glove box opening **204**, passenger airbag opening **208**, and/or boundary region **240**) a weight and cost savings can be achieved due to a decrease in amount of material necessary to be used. For example, in the depicted embodiment, placement of the reinforcement ribs **254** and the substrate ribs **250** proximate where the steering column **68** connects to the instrument panel **26** creates a stiffer connection, thus resulting in less noise, vibration and harshness experienced by a driver of the vehicle. In addition, bonding the substrate ribs **250** and the reinforcement ribs **254** to one another creates a disproportionate increase in the stiffness of the instrument panel **26** and allows for the substrate **120** and the reinforcement **150** to synergistically support the steering column **68**, which reduces noise, vibration, and harness which results from the components.

Referring now to FIG. **4**, an injection molding system **300** used for forming the instrument panel **26** is depicted that includes a heater **302**, a pump **304**, a controller **308**, a mold **312**, a pair of injection lines **316**, and a gas system **390**, according to one embodiment. The heater **302** melts a first composite **230** and a second composite **234** and the pump **304** pressurizes and forces the melted first and second composites **230**, **234** through the injection lines **316**, and into the mold **312** via connection ports **320**. The pump **304** is capable of producing high fluid pressures which permit the first and second composites **230**, **234** to be injected into the mold **312** at high pressures and speeds. Each injection line **316** engages one of the connection ports **320** on the mold **312** such that the first and second composites **230**, **234** can enter the mold **312** at different locations. In some embodiments of system **300**, more than two composite materials can be injected into the mold **312**. In these configurations, the injection molding system **300** can include separate injection lines **316** for each material and the mold **312** may contain separate connection ports **320** for each additional injection line **316**. The gas system **390** is configured to inject pressurized gas though a gas line **394** and into the mold **312** though a gas nozzle **398**.

When solidified, the first and second composite materials **230**, **234** of FIG. **4** are suitable for formation of a final component, e.g., the instrument panel substrate **120** and reinforcement **150**. The first composite **230** includes the first fiber material within the first resin. Similarly, the second composite **234** includes the second fiber material within the second resin. Accordingly, the first and second fiber materials and the first and second resins may be composed of any of the respective fibers and resins disclosed in conjunction with the instrument panel substrate **120** or the reinforcement **150**.

Again referring to FIG. **4**, the mold **312** has an A plate **324** and a B plate **328**, each plate defining approximately half of a cavity **332** of the mold **312**. The A plate **324** includes the connection ports **320** through which the first and second composite materials **230**, **234** enter the mold **312**. The A and B plates **324**, **328** each contain an impression of one half of the final vehicular component (e.g., substrate **120**, reinforcement **150**, etc.) such that when the mold **312** is closed, the negative impressions define the mold cavity **332** with the approximate dimensions of the final component. In some embodiments, the mold **312** may include inserts and/or subassemblies to aid in formation of the final component.

As shown in FIG. **5**A, the mold **312**, when configured to form a substrate **120**, has a driver-side portion **336**, a center-stack portion **340**, and a passenger-side portion **344** oriented to form the respective portions **184**, **180**, **188** of the substrate **120** (FIG. **2**). During injection of the melted first and second composites **230**, **234**, a clamping pressure is exerted on the mold **312** such that the A plate **324** and the B plate **328** are forced together. The force acting on the mold **312** prevents mold separation and flashing from occurring on the substrate **120**. The mold **312**, while depicted in a closed state in FIG. **5**A, may be opened by separating the A plate **324** and the B plate **328**. While the mold **312** is in an open state, the substrate **120** may be ejected, and the mold **312** and cavity **332** can then be cleaned. The injection molding system **300** employing mold **312** may also be used in a like manner as described above to form the reinforcement **150**, the plenum bracket **220**, or a variety of other vehicle components suitable for being fabricated with hybrid composites.

Referring now to FIG. **6**, a schematic of a method **360** using gas-assisted molding configured for formation of a final component, such as the substrate **120** of the instrument panel **26**, is provided. The method **360** includes six primary steps, labeled steps **364**, **368**, **372**, **376**, and **380**. The method **360** begins with step **364** of melting the first and second composites **230**, **234**, followed by step **368** of preparing the injection molding system **300**. Next, the step **372** of injecting the first and second melted composite materials **230**, **234** into the cavity **332** of the mold **312** is performed. Step **374** of injecting gas into the mold **312** while the first and second composites **230**, **234** are still molten is performed. The step **376** of cooling the melted first and second composites **230**, **234** to form the final component, e.g., substrate **120** of the instrument panel **26**, is conducted next. Finally, step **380** of removing the final component from the mold **312** is performed.

Referring to FIGS. **4-6**, step **364** involves heating the first and second composites **230**, **234** in the heater **302** to a temperature sufficient to melt the resin constituents. With the resins melted, the pump **304** is able to push the melted first and second composites **230**, **234** through the injection lines **316** and into the cavity **332** of the mold **312** via the connection ports **320**. The first and second composites **230**, **234**, particularly when comprising nylon resin, can be injected at a temperature between 100° C. and 400° C., and more preferably between 210° C. and 275° C. The melted first and second composites **230**, **234** typically are superheated to a sufficiently high temperature to prevent their premature solidification in the injection lines **316** before reaching the cavity **332**. As used herein, the term "superheat" refers to the temperature difference between the melting temperature and the injection temperature of the first and second composites **230**, **234**. The superheat is also necessary to ensure that the first and second composites **230**, **234** have sufficiently low viscosity to enter narrow areas of the cavity **332**. The superheat may be between 10° C. and 50° C. for composites **230**, **234**. Other injection temperatures and superheat conditions may be appropriate depending on the compositions selected for the composites **230**, **234**, geometry of the mold **312**, and other conditions.

Step **368** of preparing the injection molding system **300** may include tasks such as preheating the mold **312**, priming the injection lines **316**, priming the gas system **390**, and/or placing a preassembled fiber mat or multiple mats into the cavity **332** of the mold **312**. Step **372** of injecting the first and second composites **230**, **234** may have a duration of between 5 seconds and 30 seconds, and more preferably between 10 seconds and 20 seconds. Other durations may be appropriate for more complex mold cavity **332** geometries and/or lower melt viscosity compositions for the composites **230**, **234**. In some embodiments, the injection of the melted first and second composites **230**, **234** may be simultaneous, while in other embodiments, each composite is injected separately. During the injection step **372**, the melted first and second composites **230**, **234** are injected into respective driver-side and passenger-side portions **336**, **344** of the mold **312** (see FIG. **5**A), thereby causing substantial segregation of the fibers in the final component, e.g., substrate **120**. The composites **230**, **234** may also be injected at other points in the cavity **332** to create the desired segregation or other properties.

With particular reference to FIG. **5**A, a cross section of the mold **312** configured to produce the substrate **120** is depicted during the step **372** of injecting the first and second composite materials **230**, **234** into the cavity **332** of the mold **312**. The first and second composites **230**, **234** are injected through a series of gates (not shown). The cavity **332** may be filled by injection of the first and second composites **230**, **234** into respective driver-side and passenger-side portions **336**, **344** of the cavity **332**. Upon entering the mold **312**, the melted first and second composites **230**, **234** fluidly flow through the cavity **332** toward each other. One or more vents may be incorporated into the mold **312** proximate the center-stack portion **340**, or other areas where the first and second composites **230**, **234** meet, such that air can be expelled from the mold.

Referring now to FIG. **5**B, at a predetermined location in the cavity **332**, the melted first and second composites **230**, **234** continue to flow toward each other to combine to form the boundary region **240**. The boundary region **240** includes a mixture of fibers and resins from the first and second composites **230**, **234** and may have a width between 1 mm and 50 mm. The location and width of the boundary region **240** is controlled through design of the mold **312**, processing parameters of the injection molding system **300** and the particular composition selected for the first and second composites **230**, **234**. The processing parameters may be controlled by the controller **308** (FIG. **4**). In one exemplary embodiment, more than two composite materials having different compositions may be injected into the cavity **332** during the injection step **372**. In this configuration, there can be a boundary region **240** between each of the composite materials such that each boundary region **240** has a different composition from the other boundary regions. Upon cooling and solidification of the first and second composites **230**, **234**, the mixture of the resins and fibers within the boundary region **240** creates an integral connection between the first composite material **230** and the second composite material **234**, thereby holding the substrate **120** or other final component together.

Referring specifically to FIG. **5**C, step **374** of injecting the pressurized gas may be performed during or after filling of the mold **312** with the first and second composites **230**, **234** has been completed. In one embodiment, as the molten first and second composites **230**, **234** enter the mold **312**, portions of the first and second composites solidify or partially solidify to form a skin around a still molten core of the first and second composites **230**, **234**. The injection of gas into the first or second composites **230**, **234** is accomplished through the use of an injection nozzle **410**. The gas system **390** pressurizes the gas which travels to the injection nozzle **410** and into the cavity **332**. Injection of the pressurized gas into the core of the molten composites **230**, **234** causes an air void **414** to be formed as the molten portion of the first and second composites **230**, **234** is displaced by the pressurized gas. Simultaneously, the pressurized gas forces the solidified and partially solidified skin of the first and/or second composites **230**, **234** to take the shape of the mold **312**. As more gas is injected by the injection nozzle **410**, the air void **414** expands. In embodiments where the injection nozzle **410** is positioned proximate the substrate or reinforcement ribs **250**, **254** the air void **414** elongates and forms the substantially hollow portion of the ribs **250**, **254**. The gas system **390** may pressurize and inject a multitude of gasses including inert gasses (e.g., diatomic nitrogen, carbon dioxide, and noble gasses), pressurized air, or combinations thereof. The gas may be injected with a pressure of between about 500 psi to about 8000 psi, and more preferably between about 1000 psi and about 4000 psi. The temperature of the injected gas may be between 100° C. and 400° C., and more preferably between 210° C. and 275° C. Gas injection may be performed between about 0.1 second and about 20 seconds. Additionally, the gas may be injected into multiple locations throughout the mold **312** to form complex geometries.

Referring again to FIGS. **4-6**, step **376** of cooling the melted first and second composites **230**, **234** to form the final component, e.g., substrate **120**, occurs while the mold **312** is held under pressure and chilled. The mold **312** may be water chilled or may be air chilled to promote solidification of the final component. After solidification of the substrate **120**, the mold is opened and step **380** of removing the final component is carried out by actuating a series of ejection pins (not shown) to eject the final component from the B plate **328** of the mold **312**.

It is to be understood that variations and modifications can be made on the aforementioned structure without departing from the concepts of the present invention. For example, the present disclosure of a hybrid composite and its method of manufacture could be equally applied to the grille of a motor vehicle. Attachment points in a hybrid composite grille, for example, may require added reinforcement in the form of chopped carbon fibers and air voids could provide mounting apertures. Further, it is to be understood that such concepts are intended to be covered by the following claims unless these claims by their language expressly state otherwise.

What is claimed is:

1. A vehicular instrument panel, comprising:

a substrate comprising a first plurality of chopped carbon fibers and a first plurality of chopped glass fibers within a first nylon resin,

wherein the first plurality of chopped carbon fibers and the first plurality of glass fibers in the substrate are segregated such that the carbon fibers and the glass fibers are each substantially concentrated within respective driver-side and passenger-side portions of the substrate;

a reinforcement coupled to the substrate comprising a second plurality of chopped carbon fibers within a second nylon resin;

a reinforcement rib integrally defined by the reinforcement, the reinforcement rib being substantially hollow and positioned on a driver-side portion of the reinforcement; and

a substrate rib integrally defined by the substrate, the substrate rib being substantially hollow and positioned on the driver-side portion of the substrate,

wherein the substrate rib and the reinforcement rib are bonded to one another.

2. The vehicular instrument panel of claim **1**, wherein the first plurality of chopped carbon fibers in the substrate has a fiber volume fraction in the first nylon resin of about 15% to about 40%.

3. The vehicular instrument panel of claim **1**, wherein the substrate rib and the reinforcement rib are defined and bonded adjacent a steering column mount on the substrate.

4. The vehicular instrument panel of claim **3**, further comprising:

a duct, wherein the duct, the reinforcement, the reinforcement rib, and the substrate rib cooperatively form a hollow tube.

5. The vehicular instrument panel of claim **1**, wherein the substrate further comprises a boundary region where the first plurality of chopped carbon fibers and the first plurality of chopped glass fibers are substantially mixed.

6. The vehicular instrument panel of claim **5**, wherein the first plurality of chopped carbon fibers in the driver-side portion of the substrate has a fiber volume fraction of about 30% to 40% in the first nylon resin, the first plurality of chopped glass fibers in the passenger-side portion has a fiber volume fraction of about 30% to 40% in the first nylon resin, and the first plurality of chopped carbon fibers and the first plurality of chopped glass fibers in the boundary region each have a fiber volume fraction of about 15% to 20% in the nylon resin.

7. A vehicular instrument panel, comprising:

a first member comprising a fiber material within a first resin, the first member defining a first hollow rib; and

a second member coupled to the first member having driver-side, passenger-side, and center-stack portions, the second member defining a second hollow rib in the driver-side portion which is bonded to the first hollow rib,

wherein the driver-side portion comprises a first fiber material within a second resin, the passenger-side portion comprises a second fiber material within the second resin, and the center-stack portion comprises a mixture of the first and second fiber materials within the second resin.

8. The vehicular instrument panel of claim **7**, wherein the first and second fiber materials are each selected from the group of materials consisting of carbons, aramids, aluminum metals, aluminum oxides, steels, borons, silicas, silicon carbides, silicon nitrides, ultra-high-molecular-weight polyethylenes, A-glasses, E-glasses, E-CR-glasses, C-glasses, D-glasses, R-glasses, and S-glasses.

9. The vehicular instrument panel of claim **7**, wherein the first and second resins are each selected from the group of materials consisting of a nylon, a polypropylene, an epoxy, a polyester, a vinyl ester, a polyetheretherketone, a poly (phenylene sulfide), a polyetherimide, a polycarbonate, a silicone, a polyimide, a poly(ether sulfone), a melamine-formaldehyde, a phenol-formaldehyde, and a polybenzimidazole.

10. The vehicular instrument panel of claim **7**, wherein the first and second resins have substantially the same composition.

11. The vehicular instrument panel of claim **7**, wherein the driver-side and passenger-side portions of the second member each have a fiber volume fraction of the respective first and second fiber materials in the second resin of about 15% to about 40%.

12. The vehicular instrument panel of claim **11**, wherein the first fiber material in the driver-side portion has a first fiber volume fraction of about 30% to 40% in the second resin, the passenger-side portion has a second fiber volume fraction of about 30% to 40% in the second resin, and the first and second fiber materials in the center-stack portion each have a fiber volume fraction of about 15% to 20% in the second resin.

13. The vehicular instrument panel of claim **7**, wherein the first and second fiber materials each have an average fiber length of about 5 mm to about 7 mm.

14. The vehicular instrument panel of claim **7**, wherein the driver-side portion of the second member further comprises a fiber mat reinforcement.

15. A vehicular instrument panel, comprising:

a reinforcement comprising a plurality of chopped carbon fibers within a nylon resin, the reinforcement having a hollow reinforcement rib; and

a substrate coupled to the reinforcement comprising a plurality of chopped carbon and chopped glass fibers segregated into respective driver-side and passenger-side portions, the substrate having a hollow substrate rib,

wherein the reinforcement rib and the substrate rib are bonded to one another.

16. The vehicular instrument panel of claim **15**, wherein the plurality of chopped carbon fibers and the chopped glass fibers of the substrate are disposed in a nylon resin, further wherein the substrate has a carbon fiber volume fraction in the nylon resin of about 15% to about 40%.

17. The vehicular instrument panel of claim **15**, wherein the chopped carbon fibers in the substrate have an average fiber length of about 5 mm to about 7 mm.

18. The vehicular instrument panel of claim **15**, wherein the substrate further comprises a boundary region where the plurality of chopped carbon and glass fibers are substantially mixed.

19. The vehicular instrument panel of claim **15**, further comprising:

a duct, wherein the duct, the reinforcement, the reinforcement rib, and the substrate rib cooperatively form a hollow tube.

20. The vehicular component of claim **15**, wherein the passenger-side portion of the substrate further comprises a fiber mat reinforcement.

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